SOIL C SINK IN U.S. CROPLAND

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INTRODUCTION

Soil is a major C pool, and it has a close link with atmospheric and biotic pools. The soil C pool comprises both organic (SOC) and inorganic (SIC) components. The SOC pool is more labile and dynamic than SIC pool, and is drastically influenced by anthropogenic perturbations of soil surface. Agricultural activities with strong impact on the SOC pool comprise plowing, biomass burning, crop residue management, soil fertility management with inorganic fertilizers and organic amendments, water table management, irrigation, and cropping systems among others. These practices affect SOC content and its quality in the root zone.

THE SOC POOL IN U.S. CROPLAND SOILS

There are a few estimates of the SOC pool in U.S. soils. Waltman and Bliss (1997) estimated SOC pool in the 48 lower states at 59.4 Pg (1 Pg = petagram = 10^{15} g = 1 billion metric tons) or about 4% of the SOC pool in world soils (Table 1). Soils of Alaska contain an additional 13.5 Pg of SOC. In comparison, the SOC pool is estimated at 262 Pg for soils of Canada and 11.5 Pg for those of Mexico. Kern (1994) estimated the SOC pool of the 48 lower states in the U.S. at 78 to 84.5 Pg (Table 1). Estimates of SIC pool in soils of the U.S. are not available.

Conversion of forest to natural ecosystems has caused loss of SOC content due to erosion and mineralization. It is even more difficult to estimate the magnitude of the historic loss than of the current SOC pool. Kern (1994) estimated the loss of SOC pool ranging from 1 to 1.7 Pg. Lal et al. (1998) estimated the loss of SOC pool from U.S. cropland soils at about 5 Pg. Therefore, U.S. cropland has a potential to sequester about 5 Pg of C through agricultural intensification and adoption of recommended management practices.

RECOMMENDED MANAGEMENT PRACTICES AND C SEQUESTRATION IN SOILS

Agricultural intensification implies adoption of recommended agricultural practices on prime agricultural land for enhancing and sustaining production so that marginal agricultural land can be reverted back to restorative land uses. There are a wide range of improved agricultural practices which can lead to C sequestration (Table 2). In general, the potential of C sequestration is high for degraded soils because of high losses of C due to intensive degradative processes.

POTENTIAL OF U.S. CROPLAND FOR C SEQUESTRATION

It is difficult to estimate the total potential of U.S. cropland, because it depends on the degree of adoption of recommended agricultural practices. Assuming that identification and adoption of appropriate policies leads to a widespread adoption of improved agricultural practices, Lal et al. (1998) estimated that total potential of U.S. cropland for C sequestration in soils is 75-208 MMTC/yr. At an average of 142 MMTC/yr, this potential is about 8% of the total U.S. emissions of greenhouse gases. Agricultural practices with large C sequestration potential are conservation tillage (49%), improved cropping systems (25%), soil/land restoration (13%), land conversion (7%) and irrigation (6%). In addition, biofuel off-set through biomass production on 10 million ha of idle cropland is 32-38 MMTC/yr.

SOME IMPORTANT QUESTIONS ABOUT C SEQUESTRATION IN SOILS

Despite the vast potential of U.S. cropland, there remains numerous questions about the importance of soil C and its role in mitigating the greenhouse effect. Some of these questions are listed in Table 3. Finding answers to these questions is important to identification and implementation of appropriate policies for widespread adoption of recommended agricultural practices. Two important questions are: (i) methods of monitoring and verification of C pool and fluxes at different scales, and (ii) the monetary value of soil C for credits and trading. Finding appropriate answers to these questions requires an inter-disciplinary approach.

REFERENCES

Kern, J.S. 1994. Spatial patterns of soil organic carbon in the contiguous United States. Soil Sci. Soc. Am. J. 58: 439-455.

Lal, R., J.M. Kimble, R.F. Follett and C.V. Cole. 1998. The potential of U.S. cropland to sequester C and mitigate the greenhouse effect. Sleeping Bear Press, Ann Arbor, MI, 128pp.

Waltman, S.W. and N.B. Bliss. 1997. Estimates of SOC content. NSSC, Lincoln, NE.

Table 1. The soil organic C pool in soils of the U.S. (Pg).

SOC pool	Waltman and Bliss (1997)	Kern (1994)
U.S. lower 48 states	59.4	78-84.5
Alaska	13.5	---

Table 2. Potential of improved agricultural practices for C sequestration in soil (Lal et al., 1998).

Agricultural practice		Potential rate of C sequestration (Mg C/ha/yr)
A. Land Conversion		
(i)	Conservation Reserve Program	0.3-0.7
(ii)	Wetland Reserve Program	0.15-0.35
(iii)	Restoration of eroded land	0.3-0.7
(iv)	Mineland reclamation	1-3
(v)	Salt-affected soils	0.05-0.15
B. Improved Agricultural Practices		
(i)	Conservation tillage	0.2-0.4
(ii)	Irrigation management	0.05-0.15
(iii)	Water table management	0.05-0.15
(iv)	Fertilizer management	0.05-0.15
(v)	Winter cover crops	0.1-0.3
(vi)	Elimination of summer fallow	0.1-0.3

These rates are not additive on the same piece of land and may be maintained for 20 to 50 years.

Table 3. Some relevant questions about the importance of soils in C sequestration and greenhouse effect mitigation.

Q. 1 Why have agricultural soils been traditionally not considered as an important sink?

Answers

(a) Lack of information about soils capacity.
(b) Lack of uniform international database.
(c) Production agricultural bias.

Q. 2 What are important determinants of value of soil C for credits and trading?

Answers

(a) Nutrient supply and water holding capacity.
(b) Erosion control.
(c) Improved water quality.
(d) Mitigation of greenhouse effect.
(e) Aesthetic value.

Q. 3 What are the on-site and off-site impacts of C sequestration?

Answers

(a) On-site effects: Enhanced soil quality.
(b) Off-site effects: Improved water quality, low sedimentation in waterways, decreased transport and increased breakdown of chemicals.

Q. 4 What are direct benefits of C sequestration to farmers, especially those in developing c

Answers

(a) Improved productivity.
(b) Reduced off-farm inputs in terms of commercial fertilizers.
(c) Low risks of crop failure.

Q. 5 What are the strategies to restore degraded soils through C sequestration?

Answers

(a) Afforestation.
(b) CRP, WRP, Conservation Buffers, grass waterways.
(c) Nutrient and water management.

Q. 6 What are the national and international policies needed to make soils as C sink?

Answers

(a) Incentive payments.

(b) Credits.
(c) Policies to reduce production risks.

Q. 7 What methods are appropriate to verify C sequestration at different scales?

Answers

(a) Soil survey information.
(b) Remote sensing techniques to evaluate landuse, and use of GIS for scaling.
(c) Soil C pool and flux data from long-term experiments.
(d) Cooperation between GOs and NGOs.

Q. 8 What are the societal benefits of C sequestration?

Answers

(a) Greenhouse effect mitigation.
(b) Water quality.
(c) Pollution abatement.
(d) Restore degraded soils.
(e) Reduce need for deforestation through better use of existing lands.

Q. 9 What financial incentives may be required to restore degraded soils and promote C s

Answers

(a) Risk insurance.
(b) Incentive payment.
(c) Tax credits.
(d) Subsidies for using recommended technologies.

Q. 10 How can we foster linkages between forestry and agriculture toward C sequestration in s

Answers

(a) Joint planning meeting.
(b) Multi-disciplinary coordinated program.